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THE EFFECT OF DRYCLEANING MOISTURE ON FUSED CLOTH SYSTEMS

BY

ELIZABETH J. MORELAND

International Fabricare Institute
Silver Spring, MD 20904

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This project was initiated to investigate the effect of moisture in drycleaning systems on preselected fused cloth structures. Adverse surface distortion, such as bubbling and blistering of fusibles can occur during a drycleaning process, which also includes an appropriate finishing or restoration procedure.

Previous studies have suggested that moisture plays a key role in the unsatisfactory performance of fusibles in drycleaning. Various sources of moisture in drycleaning include:

a. garments made from hydrophilic fibers, which experience moisture regain from the environment.

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19. Abstract

- prespotting chemicals that have not been allowed to thoroughly dry before cleaning.
- necessary detergent and water additions in a charged system added to aid in water-soluble soil removal, and
- finishing or restoration procedures such as steaming or pressing.

This study examined the behavior of eight fusible systems under controlled high (84 percent ava. R.H.) versus low (50 percent ave. R.H.) solvent relative humidity levels and steaming versus pressing finishing procedures. The findings showed that increasing the relative humidity of solvent above 75 percent relative humidity (ranging from 79 to 92 percent R.H.) did not increase the number of observed samples with surface distortion. The low relative humidity levels ranged from 26 to 68 percent R.H. Open steaming produced a greater number of samples with observed surface distortion than did utility pressing, regardlass of the relative humidity level. Original bond strength values did not predict the behavior of the fused structure during drycleaning.

SUMMARY

This project was initiated to investigate the effect of moisture in drycleaning systems on preselected fused structures. Adverse surface distortion, such as bubbling and blistering of fusibles, has been noted following a complete drycleaning process, which includes an appropriate finishing or restoration procedure.

Previous studies have suggested that moisture plays a key role in the unsatisfactory performance of fusibles in drycleaning. Various sources of moisture in drycleaning include:

- garments made from hydrophilic fibers which experience moisture regain from the environment.
- prespotting chemicals that have not been allowed to thoroughly dry before cleaning.
- detergent and water additions to drycleaning solvent (called a charged system), which are necessary for removal or water-soluble soil.
- finishing or restoration procedures, such as steaming or pressing.

This study examined the behavior of eight fusible systems under controlled high (84% ave. R.H.) versus low (50% ave. R.H.) solvent relative humidity levels and steaming versus pressing finishing procedures. The findings showed that increasing the relative humidity of the solvent above 75% (ranging from 79 to 92 percent R.H.) did not increase the number of observed samples with surface distoration. The low relative humidity levels ranged from 26 to 68 percent R.H. Open steaming without pressure produced a greater number of samples with observed surface distortion than did utility pressing, regardless of the relative humidity level. Original bond strength values did not predict the behavior of the fused structure during drycleaning.

PREFACE

This project describes the effect of moisture in drycleaning systems on preselected fused cloth structures. It was undertaken by International Fabricare Institute, Silver Spring, Maryland, from February to August, 1987. This project was funded by Program Element No. 728012.12, Project No. OMA7132. The Natick Administering Contract Specialist was Donald Tullis and the Project Officer was Stephen Szczesuil.

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BACKGROUND

Three types of drycleaning solvents are presently in use in the United States. While all three are organic chemicals, their structures and properties differ. Perchloroethylene, a chlorinated hydrocarbon, is the most widely used solvent in the United States. The next most common are the several classes of petroleum solvents followed by fluorocarbon F-113. The strength or solvent power of these solvents is measured by their Kauri-Butanol Value, as determined by ASTM D 1133.[1] The characteristics of these solvents appear in Table 1.

TABLE 1. Characteristics of Common Orycleaning Solvents

	Perchloroethylene (Perc)	Fluorocarbon	Petroleum
Boiling point °F	250	117.6	300-400
Solvent Power Kauri-Butanol Value	90	31	27-45
Solubility of water in solvent (no detergent added) %/wt	.01	.01	.01
Use breakdown in US[2]	75-80%	2-3%	20-24%
Use breakdown in West Germany[3]	95%	5%	-
Use breakdown in Great Britain[4]	70%	30%	below 1%

Since perchloroethylene (perc) is the strongest of the three common drycleaning solvents, any possible damage will show up first in this solvent type. In general, it is safe to say that if no damage occurs in perc, none will occur in fluorocarbon or petroleum; whereas, the reverse is not true. For this reason, perchloroethylene was chosen as the solvent for this study.

Petroleum solvent use in Europe, which had never exceeded approximately 25-30% of the total in use, had ceased entirely by 1965,[3] due to safety regulations, higher operating costs, and higher personnel requirements. In the mid 1960s, fluorocarbon became preferred in Europe and the U.S. for sensitive articles requiring cautious cleaning. Attempts have been made to introduce 1,1,1 trichloroethane as a drycleaning solvent both in Europe and in the U.S., but to date, it has remained insignificant to the drycleaning industry because of difficulties associated with a significantly higher KB Value (KB = 124), stability, and high cost.[5]

Detergents

Drycleaning solvents are ideal for removing oils and greases and other solvent-soluble soils, but are not solely (i.e., without additives) capable of removing water-soluble soils. The purpose of the addition of detergents into drycleaning solvents (called a "charged system") is to 1) emulsify or solubilize water to promote the removal of water-soluble soil, 2) disperse insoluble soils and 3) keep soils in suspension.

The most widely used type of drycleaning detergent is anionic, which has approximately 95% of the market share. An amine sulfonate detergent was chosen for this study due to its widespread use.

For each concentration of any detergent, there is an optimum amount of moisture that will give the highest water-soluble soil removal with minimum danger to regular garments. High moisture levels in solvents can cause excessive shrinkage, wrinkling, high soil redeposition, filtration problems, and reduced removal of insoluble soil. Moisture content below the optimum level reduces water-soluble soil removal and when far below normal, may even increase soil redeposition, as a result of increased static charges.[6]

The water-holding capacity of any drycleaning detergent is a unique characteristic of that detergent. Therefore, a moisture content/RH curve must be developed for each detergent. This curve permits the estimation of solvent relative humidity of any solution of a detergent by using the revised Karl Fischer titration[7] to determine the amount of water present.

Relative Humidity

Solvent relative humidity (RH) of a charged system is determined by the ratio of the amount of water to the amount of detergent in the solution. Water is dissolved in the detergent micelles. Eventually, the solution comes to moisture equilibrium with the immersed textile and the atmosphere over the solution. At equilibrium, the water vapor pressure in all three phases must be equal. Thus, if the relative humidity of the vapor is 75%, then the solvent RH is 75% and the textile has regained or absorbed the same moisture content as it would have in air at 75% RH.

Few drycleaning machines have built-in RH sensing elements to monitor the RH of a charged system. Such devices include electric hygrometers and conductivity cells but their use is very limited today.

The relative humidity levels or ranges for this study were deliberately chosen at or below 75% for normal RH conditions and above 75% for high RH conditions. A relative humidity of 75% RH is the highest solvent RH usable before inducing the effects of felting shrinkage in all hard wool or wool-rich fabrics. A 75% RH level is the maximum RH recommended for any safe drycleaning procedure.

It should be noted that relative humidity varies with the climate in different geographical regions. These climatic differences affect the amount of moisture added to a drycleaning system by garments made from hydrophilic fibers.

Finishing

There are two main pieces of equipment used by drycleaners for finishing or pressing suit coats. One is a steam air form and the other is a utility press.

Typically, a coat is placed on a steam air form (also known as a Suzie) where low pressure steam is forced through the garment followed by air for drying. A utility press can also be used to finish lapels and the body of the coat when a high quality product is desired.

TEST PROCEDURE

The purpose of the physical testing was to investigate the effect of moisture in drycleaning on fusible interfacings by controlling solvent relative humidity levels and the finishing procedures.

The eight preassembled samples that were submitted for testing appear in Table 2.

TABLE 2. Description of Samples

ID.	Adhesive Type	Fusible Substrate	Manufacturer
A	Polyester Powder Dot	Polyester/Rayon Knit	Crown, 3404KE
B	Polyester Paste Dot	100% Polyester, nonwoven, thermal bonded	Pellon, Axcel 35
C	Polyamide Powder Dot	Polyester/Rayon, Twill Weave	Crown, 904CF
D	Polyamide Paste Dot	100% Polyester, nonwoven, spunlaced	Harodite, 7280
E	Polyamide/Polyester blended Paste Dot	100% Polyester, nonwoven, saturated bonded	Crown, 8686NF
F	Polyethylene Paste Dot	100% Cotton, plain weave	Facemate, HV 2321
G	Polyvinyl Chloride/ Polyvinyl Acetate blended Paste Dot	100% Polyester, nonwoven, Spunbonded	Harodite, 230
H	Polyamide Bi-Component (Double) Dot	Polyester/Rayon, Twill	Kufner, B241G55

All interfacings were fused to Mil-C-823 Cloth Serge; Wool and Nylon, Polyester and Wool, Type III, Class 3.

The samples were drycleaned in a 35 pound dry-to-dry refrigerated condensation perchloroethylene VIC machine Model #1035. Each sample was designated to be drycleaned in normal relative humidity conditicns (between 25-75% RH) and under high relative humidity conditions (between 75-90% RH). The drycleaning detergent used was an anionic type, anmed Perk Sheen (R) and manufactured by Adco Incorporated (Sedalia, Missouri). The detergent was used according to the manufactuerts instructions, a total of 1.0% charge, volume/volume.*

The drycleaning cycle included a 10 minute wash, 3 minute extraction, 20-30 minute drying at 140'F and 3 minute aeration. The constant dummy load consisted of 100% wool or wool blend garments. The weight of the entire load (26.5 pounds) was derived from the AATCC[7] and International Fabricare Institute recommendations for load factor based on the size of the drycleaning wheel.

Solvent characteristics, such as detergent concentration, water concentration and relative humidity were randonly evaluated during the testing process. Appendix D exhibits relative humidity determination for each normal and high drycleaning category. Water in grams/milliliter was calculated by the moisture determination by Hydranal Composite II (revised Karl-Fischer titration[8]). Detergent concentration was measured according to the Hyamine titration[9]. Percent relative humidity of the solvent was monitored by two methods: the use of an electric hygrometer (manufactured by Newport Scientific of Jessup, Maryland, formerly American Instrument Company of Silver Spring, Maryland,) and by the Perk Sheen relative humidity curve. (See Figure 1.)

Two specimens of each sample were processed under each RH condition. One specimen was designated to be pressed on a utility press after each cleaning cycle using a timed 10 second steam with the head down and a timed 10 second vacuum with a raised head. The other specimen cleaned under the same RH was open air steamed after each cleaning cycle on a Suzie form, 8 second low pressure steam, followed by 15 seconds air.

Dimensional change was recorded in percent, based on 18.0 inch benchmarks. Three warp and three fill readings were taken for each sample at interruption interval. The averages of these readings are reported. Durable press ratings were assigned based on American Association of Textile Chemists and Colorists Durable Press Replicas. Any bubbling, blistering or delamination observed was noted by each of the three independent observers and reflected in the average readings reported. Peel strength tests were performed on a low power CRE type Scott Tester X-3 according to ASTM D 2724. Three warp specimens (1x6") were tested for each sample at each interruption interval. Minimum and maximum average peel strength values (5 high, 5 low) are reported for each sample. Peel strength samples were lined with acetate or rayon lining during the drycleaning process to minimize pilling of the interfacing.

*Note that this is a true 1% vol/vol concentration; however, the manufacturer of this product advertises that there is a higher level of "active ingredient" and would therefore report this as a 2% "charge".

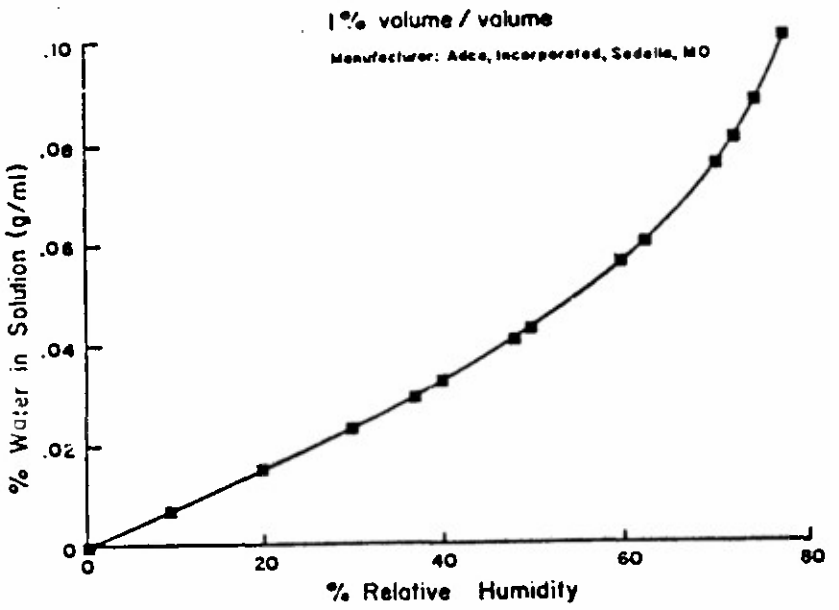

Figure 1. Perk Sheen 324® Relative Humidity Curve.

In addition, a recovery process was attempted on the samples that were drycleaned 25 cycles under high RH and steamed. These samples were pressed using the pressing conditions outlined previously and were retested for peel strength.

RESULTS

Dimensional change, durable press appearance (delamination observations) and peel strength were evaluated after 1, 5, 10, 15, 20, and 25 drycleaning cycles. See Tables 3, 4, and 5, respectively. The samples were conditioned at 70 ± 2'F, 65 ± 2% RH for 4 hours prior to any physical testing.

Those factors in this study that appear to have an effect on the visual bubbling or blistering of the test specimen include dimensional change and the finishing procedure.

Samples C, F and H demonstrated the highest dimensional change in both RH conditions and finishing conditions (see Tables 3 and 6). As a group, these three samples also demonstrated the greatest number of surface distortion citings (18). As a group, samples 8, E and D produced the lowest shrinkage results and contain only four visual surface distortions in all of the RH and finishing conditions. Previous fusible studies have suggested[9] that the shrinkage behavior of the shell fabric and fusible is critical to the appearance of fused panels after drycleaning. When shrinkage of the shell and fusible are similar, there is less chance of surface distortion.

Sample 10

TABLE 3. Dimensional Change (%) in Relation to Relative Humidity and Finishing Process

	NORM RH STEAM Oryclean Cycles						NORM RH PRESS Oryclean Cycles						HIGH RH STEAM Oryclean Cycles						HIGH RH PRESS Oryclean Cycles					
	1	5	10	15	20	25	1	5	10	15	20	25	1	5	10	15	20	25	1	5	10	15	20	15
A Warp	0.7	1.0	1.1	1.3	1.5	1.7	0.9	2.0	2.2	2.3	2.8	2.8	0.9	1.1	1.5	1.5	1.5	1.5	1.0	1.7	2.1	2.4	2.7	2.7
Fill	0.3	0.3	0.3	0.3	0.4	0.5	0.2	0.5	0.7	0.9	1.1	0.9	0.3	0.5	0.5	0.6	0.7	0.6	0.1	0.4	0.6	0.7	0.9	0.8
Total Area	1.0	1.3	1.4	1.6	1.9	2.2	1.1	2.5	2.9	3.2	3.9	3.7	1.2	1.6	2.0	2.1	2.1	2.1	1.1	2.1	3.1	3.1	3.6	3.5
B Warp	0.6	0.9	1.1	1.4	1.4	1.5	1.0	1.1	1.6	1.9	1.9	2.1	0.6	0.8	1.0	1.0	1.0	0.9	0.8	1.8	2.3	2.3	2.7	2.3
Fill	0.1	0.0	+0.1	0.2	+0.1	0.1	0.1	0.4	0.4	0.5	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.3	0.2	0.2	0.3	0.2	0.2
Total Area	0.7	0.9	1.0	1.6	1.3	1.6	1.1	1.5	2.0	2.4	2.1	2.4	0.7	0.9	1.1	1.1	1.1	0.9	1.1	2.0	2.5	2.6	2.9	2.5
C Warp	0.5	1.2	1.3	1.6	1.9	2.0	0.9	1.9	2.3	2.8	2.9	3.2	0.9	1.3	1.5	1.7	1.7	1.9	0.9	1.9	2.8	2.9	3.1	3.2
Fill	0.3	0.7	0.9	1.1	1.3	1.5	0.1	0.6	0.8	1.1	1.4	1.4	0.7	0.8	1.1	1.3	1.5	1.6	0.5	0.9	1.5	1.7	1.9	2.0
Total Area	0.8	1.9	2.2	2.7	3.2	3.5	1.0	2.5	3.1	3.9	4.3	4.6	1.6	2.1	2.6	3.0	3.2	3.5	1.4	2.8	4.3	4.6	5.0	5.2
D Warp	0.7	1.1	1.3	1.3	1.6	1.7	0.6	1.4	1.8	2.1	2.2	2.1	0.7	0.9	1.1	1.1	0.9	1.0	0.8	1.7	2.3	2.4	2.5	2.6
Fill	0.2	0.1	0.0	0.3	0.2	0.3	0.1	0.1	+0.1	0.1	0.3	0.2	0.1	0.2	0.3	0.3	0.2	0.2	0.1	+0.1	0.2	0.3	0.3	0.3
Total Area	0.9	1.2	1.3	1.6	1.7	2.0	0.6	1.5	1.7	2.2	2.5	2.3	0.8	1.1	1.4	1.4	1.1	1.3	0.9	1.6	2.5	2.7	2.8	2.9
E Warp	0.1	0.2	0.3	0.5	0.7	0.5	0.3	1.3	2.7	3.1	3.3	2.5	0.3	0.6	0.6	0.7	0.7	0.8	0.8	1.3	2.1	2.2	2.6	2.4
Fill	0.0	0.4	0.3	0.2	0.3	0.1	0.0	+0.5	0.3	1.3	0.8	0.5	0.1	0.2	0.3	0.3	0.3	0.1	+0.1	+0.1	0.3	0.5	0.7	0.9
Total Area	0.1	0.6	0.6	0.7	1.0	0.6	0.3	0.8	3.0	4.4	4.1	3.0	0.4	0.8	0.9	1.0	1.0	0.9	0.7	1.2	2.4	2.7	3.3	3.3
F Warp	0.8	1.5	1.9	2.1	2.5	2.8	0.6	2.2	2.7	3.5	4.0	4.0	1.3	1.0	2.1	2.6	2.8	2.9	1.3	2.5	3.3	4.2	4.3	4.3
Fill	0.2	0.3	0.5	0.5	0.6	0.7	0.1	1.0	0.9	1.5	1.6	1.5	0.4	0.7	0.8	0.9	1.0	0.9	0.3	1.1	1.5	1.5	1.7	1.7
Total Area	1.0	1.8	2.4	2.6	3.1	3.5	0.7	3.2	3.6	5.0	5.6	5.5	1.7	2.6	2.9	3.5	3.8	3.8	1.6	3.6	4.8	4.7	6.0	6.0
G Warp	0.3	0.7	1.1	1.3	1.4	1.7	0.9	1.5	2.2	2.5	2.8	3.1	0.9	1.3	1.7	1.9	1.9	2.0	1.0	2.2	2.7	2.9	3.1	2.9
Fill	0.1	0.1	0.1	0.3	0.3	0.4	0.1	0.3	0.6	0.8	0.8	1.0	0.5	0.6	0.6	0.7	0.5	0.7	0.4	0.4	0.9	0.9	1.0	0.9
Total Area	0.4	0.8	1.2	1.6	1.7	2.1	1.0	1.8	2.8	3.3	3.6	4.0	1.4	1.9	2.3	2.6	2.4	2.7	1.4	2.6	3.6	3.8	4.1	3.8
H Warp	0.5	1.3	1.8	1.9	2.1	2.3	0.6	1.9	3.1	3.8	4.3	4.4	1.3	1.9	2.3	2.7	3.0	3.3	1.3	2.9	4.0	4.0	6.0	6.1
Fill	0.3	0.6	0.7	0.8	0.9	1.0	+0.1	+0.2	+0.2	0.2	0.1	0.0	+0.1	0.3	0.1	0.3	0.4	0.1	+0.2	0.2	0.6	0.3	0.4	0.5
Total Area	0.8	1.9	2.5	2.8	3.0	3.3	0.5	1.7	2.9	4.0	4.4	4.4	1.2	2.2	2.4	3.0	3.4	3.4	1.1	3.1	4.6	5.2	6.4	6.6

Normal RH - below 75%
High RH - above 80%

TABLE 4. Appearance Rating of Sample Based on AATCC Three Dimensional Durable Press Replicas

Sample ID

	NORM RH STEAM Oryclean Cycles					NORM RH PRESS Oryclean Cycles					HIGH RH STEAM Oryclean Cycles						HIGH RH PRESS Oryclean Cycles					
	5	10	15	20	25	5	10	15	20	25	1	5	10	15	20	25	1	5	10	15	20	25
A	3.8	4.3	4.5	4.8	4.6*	4.7	5.0	5.0	5.0	5.0	4.2	4.2	4.8	5.0	4.8*	4.8*	5.0	5.0	5.0	5.0	5.0	4.8
B	3.2	4.0	4.2	4.2*	4.5*	4.7	5.0	5.0	5.0	5.0	3.3	3.7	3.8	4.0	4.3	4.7	5.0	5.0	5.0	5.0	5.0	4.7
C	4.0	3.5*	4.0*	4.0*	4.0*	4.8	4.8	4.8	5.0	5.0	4.2	4.3	3.7*	3.7*	3.7*	3.7*	5.0	5.0	5.0	5.0	5.0	4.5
D	3.7*	3.8	4.3	4.3	4.5	4.5	4.8*	4.8	5.0	5.0	4.0	4.2	4.3	4.3	4.8	4.7	5.0	5.0	4.8	5.0	5.0	4.8
E	3.7	3.8	4.0	4.0	4.2	4.7	2.5	2.2	3.3	4.0	4.0	3.2	4.3	4.3	4.8	4.7	4.7	4.5	4.8	4.7	4.7	4.8
F	3.8	4.0	4.0	4.0*	4.3*	4.5	4.7	5.0	5.0	5.0	3.7	3.8	4.3	4.3	4.3	4.8	5.0	5.0	4.8	4.8	5.0	4.8
G	3.5	3.7	3.8	4.2	4.3	4.7	5.0	5.0	5.0	5.0	3.7	3.7	3.7	4.2	4.5	4.3	5.0	5.0	5.0	5.0	5.0	4.7
H	3.5*	3.5*	3.5*	4.0*	3.7*	4.3	4.5	4.8	5.0	5.0	4.2	4.0	3.8	4.0*	4.3*	4.2*	4.5	4.8	5.0	5.0	5.0	4.3

AATCC Rating System

Rating	Description
5	Equivalent to DP-5 Replica - Very smooth, pressed, finished appearance
4	Equivalent to DP-4 Replica - Smooth finished appearance
3.5	Equivalent to DP-3.5 Replica - Fairly smooth, but not a pressed appearance
3	Equivalent to DP-3 Replica - Mussed, nonpressed appearance
2	Equivalent to DP-2 Replica - Rumpled, obviously wrinkled appearance
1	Equivalent to DP-1 Replica - Crumpled, creased and severely wrinkled appearance

* Indicates surface distortion (bubbling, blistering) was observed in the appearance rating

Sample 10

TABLE 5. Peel Strength (lb) in Relation to Original, Relative Humidity and Finishing Process*

		NORM RH STEAM Dryclean Cycles						NORM RH PRESS Dryclean Cycles						HIGH RH STEAM Dryclean Cycles							HIGH RH PRESS Dryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25	1	5	10	15	20	25	Rec**	1	5	10	15	20	25
A Avg High	3.6	3.0	2.4	1.9	2.4	2.0	2.0	4.2	3.0	2.2	2.8	2.9	2.5	2.7	2.3	2.1	1.7	1.9	2.1	2.3	3.8	3.5	2.5	2.0	2.1	2.2
Avg Low	2.3	1.2	1.5	0.9	1.3	1.4	1.0	2.8	2.2	1.5	1.3	1.4	1.4	1.6	1.4	0.9	1.4	0.7	0.9	0.8	2.3	1.9	1.3	1.4	1.5	1.1
B Avg High	2.2	1.3	0.8	0.6	1.3	1.2	1.6	2.0	1.3	0.8	1.8	2.0	1.9	4.1	1.9	1.3	1.2	0.9	0.9	1.1	2.9	2.5	2.0	2.0	1.7	0.8
Avg Low	0.9	1.3	0.6	0.3	0.8	0.9	0.9	1.7	1.0	0.6	1.4	1.2	1.1	1.7	0.9	0.9	1.0	0.4	1.2	0.6	1.9	1.4	1.3	1.1	0.8	0.4
C Avg High	5.1	4.5	3.4	3.3	3.2	3.2	3.5	5.2	6.1	6.1	6.7	8.3	4.8	4.0	3.2	3.7	2.9	2.4	3.1	4.4	4.7	5.5	7.5	6.7	7.2	8.3
Avg Low	2.7	2.5	1.8	1.8	1.6	2.1	1.6	2.7	3.9	3.3	4.5	3.2	2.9	2.6	2.0	2.3	1.8	1.3	1.5	3.3	1.6	3.9	4.2	4.2	2.6	6.3
D Avg High	4.5	2.0	2.0	1.9	1.9	2.4	2.6	3.5	3.3	2.1	2.2	2.4	2.0	3.0	2.7	2.1	1.8	1.6	2.0	2.2	3.2	2.8	2.6	1.5	2.2	1.6
Avg Low	2.7	1.4	1.4	1.3	0.7	1.6	1.4	2.4	1.5	1.2	1.1	1.3	0.8	1.7	1.4	1.0	0.7	0.7	1.4	0.7	1.6	1.4	1.0	0.5	0.7	0.4
E Avg High	2.0	0.8	0.5	0.5	0.4	0.6	0.5	1.4	1.3	0.4	1.2	1.0	0.9	1.5	0.5	0.4	0.2	0.6	0.4	0.7	1.3	1.1	1.2	1.0	1.0	0.8
Avg Low	1.1	0.5	0.1	0.2	0.1	0.4	0.2	0.9	0.5	0.2	0.5	0.6	0.5	0.2	0.0	0.2	0.1	0.2	0.2	0.3	0.7	0.5	0.6	0.6	0.4	0.5
F Avg High	3.5	3.8	2.7	2.8	3.1	3.0	2.8	3.5	2.6	2.7	2.9	2.9	2.5	2.8	2.5	3.3	3.0	2.7	2.6	3.8	2.6	2.7	2.8	2.6	2.8	2.2
Avg Low	2.2	1.9	1.8	1.7	1.7	2.1	1.7	1.9	1.6	1.8	2.2	2.1	1.4	1.7	1.5	2.0	2.1	1.6	1.7	2.5	1.8	1.8	2.2	1.9	2.4	1.9
G Avg High	2.4	3.3	3.0	3.5	2.8	4.3	3.3	6.4	4.7	4.2	4.2	5.4	5.4	3.0	3.0	2.5	2.4	2.0	2.9	2.6	3.5	3.2	3.6	3.0	4.2	3.6
Avg Low	1.4	1.5	1.2	1.5	1.0	3.2	1.6	2.0	1.8	2.8	1.4	2.6	2.6	2.0	1.5	1.5	1.6	1.1	1.2	1.4	2.1	2.0	1.0	0.9	1.9	2.3
H Avg High	2.6	2.2	2.7	1.4	2.2	1.9	1.7	2.9	2.4	2.6	3.7	3.6	3.2	2.3	2.2	2.5	2.2	2.2	2.6	3.5	2.5	2.5	2.6	3.0	2.0	3.3
Avg Low	1.5	1.4	1.7	0.7	1.1	1.0	1.0	0.7	1.2	1.1	2.1	2.0	1.0	1.1	1.2	1.4	1.5	1.4	1.1	1.3	1.2	1.2	1.6	1.9	1.5	1.2

*See Appendix C for individual peel strength data

**Recovery Process

TABLE 6. Dimenaional Change (%) Rankings, 25 Drycleaning Cycles

Shrinkage	High RH Press	Norm RH Presa	Norm RH Steam	High RH Steam
HIGH	H - 6.6	F - 5.5	F - 3.5	F - 3.8
	F - 6.0	C - 4.6	C - 3.5	C - 3.5
	C - 5.2	H - 4.4	H - 3.3	H - 3.4
MEDIUM	G - 3.8	G - 4.0	A - 2.2	G - 2.7
	A - 3.5	A - 3.7	G - 2.1	A - 2.1
LOW	E - 3.3	E - 3.0	D - 2.0	D - 1.3
	D - 2.9	B - 2.4	B - 1.6	B - 0.3
	B - 2.5	D - 2.3	E - 0.6	E - 0.9

Shrinkage	Delamination Citinga
HIGH	H (8), F (2), C (8)
MEDIUM	G (0), A (3)
LOW	E (0), D (2), B (2)

The samplea that demonstrated the greateat dimensional change (F, C, H) are woven substrates with different adhesives. The three samplea (E, D, B) that demonstrated the least shrinkage are nonwoven substratea with different adhesives.

The solvent relative humidity level did not appear to draatically affect dimensional change in this study; however, preaaing the samplea compared to steaming the aamplea subatantially increased the dimenaional change.

CONCLUSIONS

The dimensional change data in this report strongly suggest that those samples that exhibited the greatest dimensional change also produced the greatest number of visual surface distortions. Those samples that demonstrated the lowest dimensional change produced significantly fewer distortion citings.

Further, dimensional change consistently remains higher for pressed samples than the corresponding steamed samples. However, there were no significant dimensional change differences between the normal relative humidity and high relative humidity samples.

There were two sources of moisture in drycleaning that were varied in this test (i.e. solvent relative humidity and finishing procedures).

Results of this study indicated that increasing the relative humidity of the solvent above 75% (in the range of 79 to 92 percent R.H.) did not increase the number of observed samples with surface distortion. The low relative humidity levels ranged from 26 to 68 percent R.H. Open steaming without pressure produced a greater number of samples with observed surface distortion than did utility pressing, regardless of the relative humidity level. Original bond strength values did not predict the behavior of the fused structure during drycleaning. Previous studies[10,11,12] are referenced to confirm that relative humidity can affect surface distortion and peel strength characteristics for fusible application.

Open air steaming produced a greater number of samples with visual surface distortion than did pressing, regardless of the RH condition (Table 4). One must consider that all appearance observations were made after the finishing process. It is not possible to extract from the data whether or not the surface distortion was present before the finishing process. Should distortion have resulted from the cleaning process, the interfacings would have been refused in the pressing operation and not in the steaming operation, which would account for the unbalanced number of failures. Previous studies[10,11] have demonstrated that open air steaming increases the number of visual failures, where high steam temperature (without pressure) plasticizes and weakens the bond sites.

Historically, the original study for visual surface distortion was related to a characteristic identified as differential shrinkage. When fusibles first entered the apparel market in significant numbers in the late 1970's, extensive research (in cooperation with garment and interfacing manufacturers and drycleaners) was carried out to determine the cause of the severe surface distortion that was occurring on garments available in the marketplace. It was found by the industry at that time that differential shrinkage of the shell fabric and the interfacing was the main cause of surface distortion and garment failure being experienced by consumers.

The measurement of bond strength should not be relied on wholly for the prediction of the behavior of a fused structure during drycleaning[9,11]. This study supports the fact that high original peel strength values do not guarantee an absence of surface distortion. Conversely, lower or marginal original peel strength values do nnt guarantee surface distortion after drycleaning. Table 7 ranks comparisons of peel strength and delamination citings as shown samples C, G, and H have the highest peel values as a group, yet they contain 16 citings of visual surface distortion. Group D, E, and B has the lowest original peel values, but demonstrated only four visual failures.

Peel strength progressively deteriorates with additional drycleaning cycles (see Table 5). Peel strength consistently remains higher for pressed samples than the corresponding steamed samples. The high RH steam samples that were pressed as a recovery process showed some improvement in peel strength.

TABLE 7. Peel Strength (Lb) Ranking Comparisons, 25 Drycleaning Cycles

Peel Strength	High RH Steam	High RH Press	Norm RH Press	Norm RH Steam
HIGH	O - 8.3	C - 8.3	G - 5.4	C - 3.5
	G - 3.5	G - 3.6	C - 4.8	G - 3.3
	H - 3.3	H - 3.3	A - 3.9	F - 2.8
MEDIUM	F - 2.2	A - 2.2	H - 3.2	D - 2.6
	A - 2.2	F - 2.2	P - 2.5	A - 2.0
LOW	D - 1.5	D - 1.6	D - 2.0	H - 1.7
	E - 0.8	E - 0.8	B - 1.9	B - 1.6
	B - 0.8	B - 0.8	E - 0.9	E - 0.5

Peel Strength	Delamination Citings
HIGH	C (8), G (0), H (8)
MEDIUM	F (2), A (3)
LOW	D (2), E (0), B (2)

An assessment of peeling strength relative to fusible adhesive types shows that the expected drycleanable resistant adhesives such as polyamide powder dot, polyamide bi-component (double) dot, and the polyvinyl chloride/polyvinyl acetate blended paste dot systems provided excellent peeling strengths. The difficulty in assessing the remaining adhesive types is that when they are used on certain nonwoven substrates, the nonwoven structure itself is weaker than the apparent adhesive bonding strength. Furthermore, while the polyester powder dot and polyethylene paste dot type fusibles demonstrated reasonable peeling strengths, it must be noted that they typically would be used in launderable type end-item applications.

RECOMMENDATIONS

Further study (perhaps of a more limited scope) would more carefully evaluate the role of dimensional change in the delamination of the fusibles in this study. It would be beneficial to evaluate the dimensional change of each component separately (i.e., the outershell and the interfacing) compared to the dimensional change and delamination of the bonded system.

As previously mentioned, there is a problem with extrapolating data regarding the effects of the finishing procedure. Due to the prescribed test outline, it is not possible to determine if separation resulted before, during or after the finishing procedure. It is conceivable that pressing only retacked the separated bonded system.

IFI recommends to its membership the following procedures for processing fusibles:

- moderate drycleaning cycle length: 10 minutes perc, 15 minutes fluorocarbon, 20 minutes petroleum.
- drying at 140°F (stack temperature): 15 minutes perc, 25 minutes petroleum, 10 minutes fluorocarbon.
- 60-65% solvent R.H.
- prespotted areas must be completely dry (of moisture) before processing.
- steam air from 5-8 seconds, forced air dry 15 seconds.

IFI contends that complete pressing is not always necessary for optimum finishing, but that pressing is necessary where separation requires retacking.

The recommended care label for the eight submitted fusibls systems in compliance with the FTC Care Labeling Rule is:

Professionally Dryclean
Utility Press

Restoration Procedure - Retacking

The recommended restoration procedure for fusibles that require retacking is as follows:

1) bring the affected area of the garment up to temperature by alternately steaming and vacuuming five seconds each.

2) align the interfacing and the shell fabric.

3) press five seconds with the head down.

4) apply vacuum for five seconds before raising the head, which maintains contact and speeds cooling.

Head pressure should not be used in padded or detailed areas of the coat. Head pressure should not be used on gabardines, velvets or corduroys, which would result in surface distortion or damage.

Previous experience with retacking fusibles has indicated that a restoration procedure has ultimately limited applicability with actual garments. Re-fusing becomes less effective with each successive retacking and as the age and use of the article increases.

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APPENDIXES

A. Material Safety Data Sheet: Perchloroethylene Industrial *

B. Material Safety Data Sheet: Perk Sheen 324 **

C. Individual Peel Strength Data

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APPENDIX A

MATERIAL SAFETY DATA SHEET

Dow Chemical U.S.A. Midland, MI 48674 Emergency Phone: 517-636-4400

Product Code: 59009 Page: 1

PRODUCT NAME: PERCHLOROETHYLENE INDUSTRIAL

Effective Date: 04/10/85 Date Printed: 01/03/86 MSDS:000190

1. INGREDIENTS:

Tetrachloroethylene	CAS# 000127-18-4	99.9%

2. PHYSICAL DATA:

BOILING POINT: 250F (121.1C)
VAP PRESS: 13 mmHg @ 20C
VAP DENSITY: 5.76
SOL. IN WATER: 0.015 g/100g 25C
SP. GRAVITY: 1.619 @ 25/25C
APPEARANCE: Colorless liquid.
ODOR: Not available.

3. FIRE AND EXPLOSION HAZARD DATA:

FLASH POINT: None
METHOD USED: TOC, TCC, COC

FLAMMABLE LIMITS
LFL: None
UFL: None

EXTINGUISHING MEDIA: Non-flammable material.

FIRE & EXPLOSION HAZARDS: No autoignition temperature.

FIRE-FIGHTING EQUIPMENT: Wear positive pressure self-contained raspiratory equipment.

(Continued on Page 2)

MATERIAL SAFETY DATA SHEET

4. REACTIVITY DATA:

STABILITY: (CONDITIONS TO AVOID) Avoid open flames, welding arcs, or other high temperature sources which induce thermal decomposition.

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) Strong acids and oxidizing materials.

HAZARDOUS DECOMPOSITION PRODUCTS: Involvement in fire forms hydrogen chloride and small amounts of phosgene and chlorine.

HAZARDOUS POLYMERIZATION: Will not occur.

5. ENVIRONMENTAL AND DISPOSAL INFORMATION:

ACTION TO TAKE FOR SPILLS/LEAKS: Small leaks - mop up, wipe up, or soak up immediately. Remove to out of doors. Large spills - evacuate area. Contain liquid; transfer to closed metal containers. Keep out of water supply.

DISPOSAL METHOD: When disposing of the unused contents, the preferred options are to send to licensed reclaimer, or to permitted incinerators, in compliance with local, state, and federal regulations including Subtitle C of The Resource Conservation and Recovery Act. Dumping into sewers, on the ground, or into any body of water is strongly discouraged, and may be illegal. Consult The Dow Chemical Company for further information.

6. HEALTH HAZARD DATA:

EYE: May cause pain, and slight transient irritation. Vapors may irritate the eyes at about 100 ppm.

SKIN CONTACT: Short single exposure not likely to cause significant skin irritation. Prolonged or repeated exposure may cause some skin irritation, even a burn. Repeated contact may cause drying or flaking of skin.

(Continued on Page 3)

6. HEALTH HAZARD DATA: (CONTINUED)

SKIN ABSORPTION: A single prolonged skin exposure is not likely to result in absorption of harmful amounts. The LD50 for skin absorption in rabbits is >10,000 mg/kg.

INGESTION: Single dose oral toxicity is low. The LD50 for rats is >5000 mg/kg. If aspirated (liquid enters the lung), may be rapidly absorbed through the lungs and result in injury to other body systems.

INHALATION: Dizziness may occur at 200 ppm; progressively higher levels may also cause nasal irritation, nausea, incoordination, drunkenness; and over 1000 ppm, unconsciousness and death. A single brief (minutes) inhalation exposure to levels above 6000 ppm may be immediately dangerous to life. In confined or poorly ventilated areas vapors can readily accumulate and can cause unconsciousness and death. Alcohol consumed before or after exposure may increase adverse effects.

SYSTEMIC & OTHER EFFECTS: Excessive exposure may cause anesthetic or narcotic effects, central nervous system effects, and liver and/or kidney effects. The preponderence of information indicates perchloroethylene is not likely to be a carcinogen in man although one lifetime study with toxic doses of perchloroethylene given by stomach tube indicated a carcinogenic response in laboratory mice, but not in rats exposed by ingestion or inhalation. Birth defects are unlikely. Although in laboratory animals other adverse effects were observed in the mother and fetus at exaggerated doses, exposures having no effect on the mother should have no effect on the fetus. Results of in vitro ("test tube") mutagenicity tests have been negative.

7. FIRST AID:

EYES: Irrigate immediately with water for at least 5 minutes.

SKIN: Wash off in flowing water or shower. Wash contaminated clothing before reuse.

(Continued on Page 4)

MATERIAL SAFETY DATA SHEET

Dow Chemical U.S.A. Midland, MI 48674 Emergency Phone: 517-636-4400

PRODUCT NAME: PERCHLOROETHYLENE INDUSTRIAL

Effective Date: 04/10/85 Date Printed: 01/03/86 MSDS:000190

7. FIRST AID: (CONTINUED)

INGESTION: Do not induce vomiting. Call a physician and/or transport to emergency facility immediately.

INHALATION: Remove to fresh air. If not breathing, give mouth-to-mouth resuscitation. If breathing is difficult, give oxygen. Call a physician.

NOTE TO PHYSICIAN: Because rapid absorption may occur through lungs if aspirated and cause systemic effects, the decision of whether to induce vomiting or not should be made by a physician. If lavage is performed, suggest endotracheal and/or esophageal control. Danger from lung aspiration must be weighed against toxicity when considering emptying the stomach. If burn is present, treat as any thermal burn, after decontamination. Exposure may increase "myocardial irritability". Do not administer sympathomimetic drugs unless absolutely necessary. No specific antidote. Supportive care. Treatment based on judgment of the physician in response to reactions of the patient.

8. HANDLING PRECAUTIONS:

EXPOSURE GUIDELINE(S): Perchloroethylene: ACGIH TLV is 50 ppm (stel is 200 ppm); OSHA PEL is 100 ppm.

VENTILATION: Control airborne concentrations below the exposure guideline. Use only with adequate ventilation. Local exhaust ventilation may be necessary for some operations. Lethal concentrations may exist in areas with poor ventilation.

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guideline. When respiratory protection is required for certain operations, use an approved air-purifying respirator. In confined or poorly ventilated areas, use an approved positive pressure self-contained breathing apparatus.

SKIN PROTECTION: Use protective clothing impervious to this material. Selection of specific items such as gloves, boots, apron, or full-body suit will depend on operation. Remove

(Continued on Page 5)

MATERIAL SAFETY DATA SHEET

Dow Chemical U.S.A. Midland, MI 48674 Emergency Phone: 517-636-4400

PRODUCT NAME: PERCHLOROETHYLENE INDUSTRIAL

Effective Date: 04/10/85 Date Printed: 01/03/86 MSDS:000190

8. HANDLING PRECAUTIONS: (CONTINUED)

contaminated clothing immediately, wash skin area with soap and water, and launder clothing before reuse.

EYE PROTECTION: Where contact with liquid is likely, chemical goggles are recommended because eye contact with this material may cause pain, even though it is unlikely to cause injury.

9. ADDITIONAL INFORMATION:

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Handle with reasonable care and caution. Avoid breathing vapors. Vapors of this product are heavier than air and will collect in low areas such as pits, degreasers, storage tanks, and other confined areas. Do not enter these areas where vapors of this product are suspected unless special breathing apparatus is used and an observer is present for assistance.

MSDS STATUS: Revised 1, 6, 7, and 8.

APPENDIX B

MATERIAL SAFETY DATA SHEET

PRODUCT PERK SHEEN 324

since 1908

HAZARD RATINGS*

-OSHA-

Health	1	slight health hazard
Fire	1	slightly combustible
Reactivity	0	nonreactive

-N.F.P.A.-

DOT Class:
unregulated

I - PRODUCT IDENTIFICATION

Manufacturer: ADCO, Inc. 900 W. Maio, Sedalia, MO 65301

Emergency Telephone nos: CHEMTREC (800) 424-9300; ADCO,Ioc. (800) 821-7556

Intended use detergentl for drycleaning garments

Chemical name none - proprietary mixture CAS# oooe

Synonyms drycleaning "soap" State registry# peoding

II - PHYSICAL DATA

Appearance orange-yellow syrup Flash point 340 - 355°F (C.O.C.)

Odor bland % volatile (220°F) none

Specific gravity .973 @ 68°F pH (water solution) 5.0 - 5.5

Solubility in water slight - dispersible

III - HAZARDOUS INGREDIENTS

☐ none ☒ proprietary mixture ☐ not applicable

☒ Ingredients are considered hazardous only as eye or skin irritants.

_____ CAS # _____

_____ CAS # _____

IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point: 340 - 355°F (C.O.C.) Lower Flammable Limit: not applicable

Extinguishing Media: dry chemicals, carbon dioxide, water fog

Special Fire Fighting Procedures: Avoid directing strong water stream ioto product – may generate foam.

Unusual Fire and Explosion Hazards: High heat may produce ooxious decomposition products.

*Hazard ratings and other information are based on latest available information from tests on product or ingredients of mixtures. The data and evaluations are accurate to the best of ADCO's knowledge. No guarantee or liability is expressed or implied.

APPENDIX B

V - HEALTH HAZARD DATA

Threshold Limit Value: not applicable Toxicity: low ☒ Estimated. No test data on this mixture is available.

Effects of Overexposure: Acute: Causes drying and irritation in eyes or on prolonged contact with skin.
Chronic: None known

First Aid Procedures: Flush eyes with water (15 minutes).
Wash skin with soap and water.
If swallowed: do not induce vomiting.

IF SYMPTOMS PERSIST SEEK MEDICAL ASSISTANCE

VI - REACTIVITY DATA

Stability: ☒ Stable ☐ Unstable Conditions to Avoid: high heat

Incompatibility(materials to avoid): strong oxidizers, strong alkali

Hazardous Decomposition Products: amines, ammonia and irritating fumes

Hazardous Polymerization: ☒ Will not Occur

VII - SPILL OR LEAK PROCEDURES

Steps to be taken if material is spilled: Small spills may be flushed to sewer with water. Larger spills - soak up with absorbent material and place in containers for disposal (nonhazardous waste).

Waste Disposal Method: Not a hazardous waste. Flush to sewer or dispose of materials and container in nonhazardous landfill.

VIII - SPECIAL PROTECTION INFORMATION

Respiratory Protection: ☒ None required when used as directed with adequate ventilation.
☐ When cleaning up large spills in confined areas, self-contained breathing apparatus is recommended.

Ventilation: ☒ Normal industrial ventilation is adequate. ☐ Use in a spray booth.
☐ Local exhaust at work station recommended.

Protective Gloves: ☒ Ordinarily not needed. Use gloves when contact is prolonged or frequent.

Eye Protection: ☐ Use goggles or face mask if splashing is likely.

Other protection Equipment: ☒ Ordinarily not needed. Availability of eye washes in work areas recommended.

Recommended Precautionary Labeling:

Caution: May cause irritation if splashed in eyes.
May cause skin irritation on prolonged contact.
Do not take internally.

First aid: Flush with water.
Do not induce vomiting if swallowed.

IX - OTHER SPECIAL PRECAUTIONS

This product is intended for professional use only by trained personnel.

KEEP OUT OF REACH OF CHILDREN. DO NOT TAKE INTERNALLY.

Clean up spills on walkways to prevent slick spots.

This information is provided for guidance only based on information we have. No guarantee of accuracy or completeness is expressed or implied.

Prepared by Robert Risner Date 9/4/85

Robert Risner

APPENDIX C

Individual Peel Strength Data

Peel Strength (lb) in Relation to Original, Relative Humidity and Finishing Process of Sample A, Polyester Powder Dot.

	NORMAL RH WITH STEAM Oryclean Cycles							NORMAL RH WITH PRESS Oryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individual Highs	3.5	3.5	2.5	2.0	2.5	2.0	2.5	6.0	3.5	2.5	3.0	3.1	3.1
	3.0	3.0	2.5	2.0	2.5	2.0	2.0	4.5	3.0	2.0	3.1	3.0	3.0
	4.0	3.5	2.0	2.0	2.5	2.0	1.5	4.0	3.0	2.0	3.0	3.0	3.0
	4.0	2.5	2.5	1.7	2.5	2.0	2.0	3.3	2.5		2.7	2.9	2.0
	3.5	2.5	2.5	1.7	2.0		2.0	3.2	3.0		2.4	2.5	1.6
Individual Lows	2.0	1.5	1.5	0.5	1.7	1.0	1.6	3.0	1.5	1.5	0.3	0.7	1.2
	2.5	1.5	1.5	0.5	1.5	1.0	1.5	3.0	2.1	1.6	1.6	1.4	1.3
	2.0	1.5	1.5	1.0	1.5	1.5	0.8	3.0	2.5	1.5	1.7	1.5	1.3
	2.5	1.5		1.5	1.5	1.8	0.8	2.5	2.5		1.7	1.7	1.3
	2.5	1.0			1.3	1.8	1.4	2.5	2.3			1.8	2.0

	HIGH RH WITH STEAM Oryclean Cycles							HIGH RH WITH PRESS Oryclean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	2.8	2.5	2.3	1.5	2.0	2.3	2.5	4.4	4.3	2.6	2.5	2.0	2.5
	2.7	2.4	2.0	1.9	1.5	2.2	2.3	4.4	4.0	2.8	2.2	2.2	1.9
	2.7	2.3	2.1	1.6	2.0	2.1	2.4	3.6	3.1	2.5	2.0		2.4
	2.7	2.3	2.0		2.0	2.0	2.0	3.5	3.0	2.3	1.6		2.0
		1.8	1.9		1.9	1.8	2.5	3.3	3.3	2.1	1.7		2.0
Individual Lows	1.4	1.0	1.1	1.4	0.5	0.3	0.5	2.0	1.1	0.7	0.8	0.7	0.5
	1.6	1.2	0.1	1.5	0.9	1.5	1.2	2.1	2.0	1.0	1.5	1.2	1.0
	1.6	2.0	1.5	1.3	0.6	0.6	0.5	2.5	2.0	1.6	1.8	1.5	1.2
	1.5	1.5		1.2	0.7	0.8	0.4	2.3	2.0	2.0	1.9	2.0	1.3
	2.0	1.5		1.5		1.5	1.5	2.6	2.4	1.4	0.9	2.0	1.7

* 25 Oryclean cycles with steam, followed by one press.

APPENOIX C

Individual Peel Strength Oata

Peel Strength (lb) in Relation to Original, Relative Humidity and Finishing Process of Sample B, Polyester Paste Oot.

	NORMAL RH WITH STEAM Oryclean Cycles							NORMAL RH WITH PRESS Oryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individual Highs	2.5	1.5	1.1	0.6	1.5	1.0	0.9	2.5	1.6	1.0	1.9	2.2	1.9
	2.5	1.0	0.6	0.6	1.5	1.0	1.9	1.6	1.0	0.7	1.9	2.2	1.9
	2.4	1.1	0.7	0.7	1.0	1.5	1.5	2.0	1.3	0.8	1.9	2.2	1.9
	2.0	1.4			1.3	1.3	1.9	1.9	1.2		1.3	1.5	1.9
	1.6				1.4		1.6					1.9	1.9
Individual Lows	0.5	1.0	0.5	0.3	0.5	1.0	1.0	2.2	0.5	0.5	1.2	1.3	0.7
	0.3	1.3	0.3	0.4	0.5	0.6	0.9	2.1	1.1	0.5	1.7	1.0	1.3
	1.1	1.5	0.7	0.3	1.1	1.1	1.3	1.8	1.5	0.8	1.0	1.1	1.0
	1.3		1.0		1.0		0.7	1.3			1.5	1.3	1.0
	1.4						0.7	1.0			1.5	1.5	1.4

	HIGH RH WITH STEAM Dryclean Cycles							HIGH RH WITH PRESS Oryclean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	4.9	2.3	1.4	1.2	0.7	1.0	1.3	3.3	3.3	2.5	1.6	1.8	1.3
	4.1	2.2	1.5	1.2	1.0	1.0	1.1	3.0	2.4	2.6	2.1	2.0	0.7
	3.9	2.1	1.1	1.1	0.9	0.8	1.0	2.5	2.4	2.0	1.8	1.3	0.7
	3.8	1.5	1.2	1.1			1.1	2.6	2.0	1.4	2.0	1.7	0.9
	3.6	1.3						3.0		1.3	2.4		0.6
Individual Lows	1.0	0.5	1.0	1.0	0.5	1.1	0.8	1.5	1.0	1.0	0.5	0.7	0.3
	1.8	1.0	1.0	1.0	0.3	1.1	0.5	1.8	1.1	1.5	1.0	0.5	0.5
	1.9	1.0	0.7		0.4	1.2	0.5	2.1	1.5	1.5	1.2	1.1	0.3
	1.7	1.1				1.2		2.1	1.7		1.2	0.8	
	1.9							2.2	1.5		1.4		

* 25 Oryclean cycles with steam, followed by one press.

APPENOIX C

Individual Peel Strength Data

Peei Strength (lb) in Relation to Original, Relative Humidity and Finishing Process of Sample C, Polyamide Powder Oot.

		NORMAL RH WITH STEAM Oryclean Cycles						NORMAL RH WITH PRESS Oryciean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individuai Highs	6.1	4.6	4.0	3.6	3.4	3.2	3.6	5.6	6.1	6.6	7.5	9.1	6.0
	5.5	4.6	3.5	3.5	3.3	3.4	3.8	5.7	6.1	6.5	6.8	9.2	5.4
	4.5	5.2	3.4	3.4	3.3	2.6	3.9	5.0	6.1	5.9	6.4	9.1	4.3
	4.5	4.3	3.2	3.2	3.1	3.4	3.4	5.1	6.1	5.9	6.0	8.9	4.2
	5.0	3.8	2.9	2.9	2.8	3.3	2.9	4.4	6.0	5.5		5.0	3.9
Individual Lows	3.5	3.0	2.2	0.7	1.9	1.5	2.0	2.0	5.0	2.2	6.0	0.6	2.4
	3.7	3.3	2.6	1.9	0.5	2.3	2.0	1.5	4.0	3.5	5.1	3.2	3.0
	2.6	2.4	2.6	1.8	1.5	1.8	0.3	2.5	4.1	4.4	4.0	3.6	2.4
	2.4	2.2	1.0	2.4	2.0	2.5	1.4	3.6	3.4	3.0	3.9	4.6	3.1
	1.5	1.8	0.4	2.0	2.1	2.2	2.4	3.7	3.1		3.5	4.0	3.4

	HIGH RH WITH STEAM Oryclean Cycles							HIGH RH WITH PRESS Dryciean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	4.4	3.4	4.0	3.2	2.6	3.5	4.6	5.2	6.9	8.6	7.4	8.0	9.5
	4.2	3.1	3.7	3.0	2.5	3.0	4.5	5.0	6.0	8.9	6.9	7.1	8.0
	4.0	3.1	3.5	2.9	2.5	3.0	4.1	4.5	5.5	7.2	6.9	7.0	7.5
	4.2	3.2	3.5	2.5	2.3	2.9		4.4	4.6	6.8	6.3	6.6	8.0
	3.3	3.0		3.0	2.3	2.9		4.4	4.6	6.0	6.0		
Individual Lows	2.6	2.5	1.3	1.6	2.0	1.2	3.1	1.5	3.5	5.2	3.5	1.9	5.1
	2.0	2.2	2.3	1.6	1.8	1.8	3.2	2.5	4.0	4.2	4.0	1.6	7.0
	3.1	2.6	2.5	1.6	1.0	1.8	3.4	2.3	4.0	4.6	4.4	3.2	6.3
	2.6	2.6	2.6	1.8	1.0	1.1	3.3	3.5	3.6	3.8	4.8	4.5	6.4
	2.7		3.0	2.2	0.7	1.6		3.0	4.2	3.0		2.0	6.9

* Dryciean 25 cycles with steam, followed by one press.

APPENOIX C

Individual Peel Strength Oata

Peel Strength (lb) in Relation to Original, Relative Humidity and Finishing Process of Sample 0, Polyamide Paste Dot.

		NORMAL RH WITH STEAM Oryclean Cycles						NORMAL RH WITH PRESS Oryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individual Highs	5.2	2.5	2.4	2.0	2.0	2.5	2.8	3.7	3.7	2.5	2.5	3.0	2.7
	5.2	2.2	2.2	2.0	2.0	2.4	2.6	3.6	3.7	2.2	2.3	2.4	2.3
	4.5	1.8	1.8	2.0	2.0	2.5	2.5	3.5	3.6	2.0	2.2	2.4	2.3
	4.5	1.8	1.8	1.8	1.7	2.3	2.5	3.4	3.0	1.9	2.2	2.1	1.7
	3.5	1.8	1.8	2.0	1.7	2.3	2.5	3.4	2.5	1.7	2.0	2.0	1.5
Individual Lows	2.7	1.5	1.6	1.4	1.2	1.5	1.7	2.6	1.0	1.3	1.8	1.8	1.0
	2.7	1.5	1.5	1.2	1.0	1.5	1.6	2.5	1.4	1.2	1.5	1.5	1.1
	3.0	1.5	1.5	1.2	0.7	1.7	1.5	2.6	1.8	1.2	1.5	1.5	0.5
	2.9	1.5	1.4	1.3	0.5		1.5	2.6	1.6		0.6	0.3	0.4
	2.0	1.2	1.1	1.2	0.2		0.5	1.5	1.5		0.2		

	HIGH RH WITH STEAM Oryclean Cycles							HIGH RH WITH PRESS Oryclean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	3.4	2.9	2.4	2.1	1.7	2.1	2.7	3.9	3.5	3.0	2.0	2.5	1.7
	3.2	2.8	2.3	2.0	1.5	2.1	2.6	3.4	2.7	2.7	1.5	2.4	1.8
	2.8	2.7	2.3	1.4	1.5	2.0	2.2	3.0	2.7	2.5	1.4	2.0	1.5
	2.9	2.6	2.0		1.6	1.9	2.0	3.0	2.6	2.5	1.0	2.1	1.3
	2.7	2.7	1.6				1.5	2.5	2.5	2.5			
Individual Lows	1.0	1.1	1.4	1.0	0.6	1.5	1.0	2.2	1.9	1.7	0.5	0.5	0.8
	1.7	1.3	1.1	1.1	0.7	1.2	1.0	1.8	1.7	1.5	0.4	0.4	0.5
	1.7	1.4	0.3	0.6	0.8	1.5	1.2	1.6	1.5	0.7	0.5	0.3	0.4
	2.0	1.6		0.1			1.1	1.5	1.0	0.7		1.4	0.1
	2.0	1.7					0.1	1.0	1.0	0.3			

* Dryclean 25 cycles with steam, followed by one press.

APPENOIX C

Individual Peel 5trength 0ata

Peel 5trength (lb) in Relation to Original, Relative Humidity and Finishing Process of 5ample E, Polyamide/Polyester Blended Paste 0ot.

		NORMAL RH WITH 5TEAM Oryclean Cycles						NORMAL RH WITH PRE55 Oryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individual Highs	2.8 2.4 1.8 1.5 1.5	0.6 1.0 0.9	0.5 0.5	0.5 0.4	0.4	0.5 0.6	0.5	1.3 1.5	1.4 1.1	0.3 0.4	1.2 1.1	1.0 0.9	0.8 0.9 0.9
Individual Lows	1.2 0.8 1.3 0.9	0.4 0.5 0.5	0.1 0.1	0.1 0.3	0.0 0.1	0.3 0.4	0.2	0.6 1.1	0.4 0.5	0.1 0.2	0.3 0.6 0.7	0.5 0.7	0.4 0.5 0.5

	HIGH RH WITH 5TEAM Oryclean Cycles							HIGH RH WITH PRE55 Oryclean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	2.4 2.0 1.0 0.6	0.5	0.5 0.3	0.2	1.0 0.2 0.7	0.4	0.9 0.8 0.5	1.5 1.3 1.2	1.1 1.0	1.2 1.3 1.1 1.0	1.0	1.2 0.8	0.8 0.7
Individual Lows	0.1 0.2 0.3	0.0	0.2	0.1	0.5 0.2 0.0	0.2	0.1 0.4 0.5	0.5 0.5 0.7 0.9	0.5 0.5	0.5 0.2 1.0	0.5 0.7	0.2 0.4 0.5	0.4 0.5

* 25 Oryclean cycles with steam, followed by one press.

APPENDIX C

Individual Peel Strength Data

Peel Strength (lb) in Relation to Original, Relative Humidity and Finishing Process of Sample F, Polyethylene Paste Dot.

		NORMAL RH WITH STEAM Dryclean Cycles						NORMAL RH WITH PRESS Dryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individual Highs	4.0	3.5	3.6	3.4	3.8	3.0	3.5	4.3	2.4	3.1	3.1	3.0	2.5
	3.9	3.4	2.8	2.9	3.5	3.0	2.4	4.1	3.0	3.0	2.5	2.9	2.5
	3.8	2.9	2.5	2.7	3.4	3.0	2.6	3.3	2.5	2.1	3.1	2.7	2.5
	3.1	2.6	2.3	2.0	2.7			3.2	2.4	2.6		3.0	2.5
	2.6	2.8	2.2		2.3			2.6					
Individual Lows	2.0	2.2	1.6	1.5	2.0	2.5	1.5	1.7	0.6	1.7	1.5	2.2	0.5
	2.3	1.5	1.7	1.5	1.5	2.1	1.7	2.0	1.5	1.8	2.3	2.1	2.0
	2.3	1.7	2.0	2.0	1.6	2.0	1.7	2.2	2.5	1.8	2.4	2.1	1.6
		2.1	1.7		1.7	2.1	2.0	1.5	1.8	1.8	2.4		
						1.8		2.0	1.8	2.0			

	HIGH RH WITH STEAM Dryclean Cycles							HIGH RH WITH PRESS Dryclean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	3.0	2.8	4.0	3.3	3.1	2.5	4.5	2.6	3.2	3.0	3.1	2.8	2.5
	2.5	2.8	4.1	2.9	2.4	2.6	4.0	2.7	2.6	2.9	2.5	2.7	2.3
		2.2	2.9	2.9	2.5	2.6	3.7	2.8	2.6	2.8	2.5		2.2
		2.1	2.6	2.9		2.6	3.5	2.3	2.3	2.8	2.6		2.2
		2.8	2.7			2.5	3.5	2.7		2.7	2.2		1.9
Individual Lows	2.0	1.6	1.5	1.8	1.5	2.0	1.0	1.7	1.8	2.0	1.8	2.3	1.7
	1.4	1.5	2.3	2.3	1.3	1.1	3.0	2.0	2.0	2.3	1.9	2.5	2.0
		1.5	2.0	1.9	1.6	2.0	3.0	1.8	1.8	2.3	2.1	2.3	2.1
			2.1	2.2	1.8		2.5		2.1				1.9
							2.9		1.7				2.0

* Dryclean 25 cycles with steam, followed by one press.

APPENDIX C

Individual Peel Strength Oata

Peel Strength (lb) in Relation to Original, Relative Humidity and and Finishing Process of Sample G, Polyvinyl Chloride/Polyvinyl Acetate Blended Oot.

		NORMAL RH WITH STEAM Oryclean Cycles						NORMAL RH WITH PRESS Oryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individual Highs	2.6	3.6	3.4	4.4	3.0	4.8	3.5	6.0	5.4	5.2	4.7	5.6	6.0
	2.5	3.6	3.4	4.1	2.9	4.6	3.4	5.8	4.8	4.5	4.3	5.6	6.0
	2.4	3.5	3.0	3.1	2.8	4.2	3.4	4.8	4.5	4.0	4.1	5.5	5.5
	2.0	3.5	2.7	3.0	2.8	4.0	3.2	4.8	4.2	3.9	4.1	5.3	4.8
	2.5	3.3	2.8	3.0	2.5	4.0	3.0	4.6	3.9	3.5	4.0	5.2	4.5
Individual Lows	1.7	3.0	2.4	0.0	1.8	3.5	2.7	1.5	0.2	2.5	3.0	1.7	1.5
	1.6	1.8	1.2	1.5	1.5	3.0	2.2	2.0	1.7	2.5	3.1	2.3	2.5
	1.0	1.2	1.0	1.8	1.5		1.7	2.4	2.0	2.6	0.3	2.7	2.6
	0.5	0.0	0.8	2.0	0.5		1.0	2.4	2.6	3.3	0.3	2.9	2.9
	0.2		0.5	2.4	0.0		0.3	2.0	2.5	3.2	0.3	3.0	3.3

	HIGH RH WITH STEAM Oryclean Cycles							HIGH RH WITH PRESS Oryclean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	3.2	3.2	2.7	2.7	2.0	3.6	2.6	3.9	3.5	4.1	3.4	4.5	3.9
	3.0	3.1	2.5	2.7	2.1	3.4	2.6	3.4	3.4	3.7	2.9	4.4	3.8
	3.1	3.0	2.4	2.7	2.2	2.8	2.6	3.1	3.2	3.5	3.0	4.2	3.7
	3.0	3.0	2.4	2.1	1.8	2.4	2.5		3.2	3.5	3.0	4.0	3.5
	2.7	2.7	2.5	2.0	1.7	2.4	2.5		2.7	3.0	2.7	3.7	3.0
Indivdual Lows	1.7	0.0	2.0	1.7	1.0	0.3	0.2	2.7	2.0	2.0	0.1	2.7	2.2
	2.0	1.5	2.0	1.6	1.0	2.0	1.7	0.5	1.9	1.7	1.7	2.6	2.2
	2.0	2.0	1.9	1.6	1.4	1.7	1.7		2.0	1.0		1.8	2.3
	2.4	2.4	0.1			1.5	1.7			0.3		1.9	2.4

* Oryclean 25 cycles with steam, followed by one press.

APPENDIX C

Individual Peel Strength Data

Peel Strength (lb) in Relation to Original, Relative Humidity and Finishing Process of Sample H, Polyamide Bi-Component (Double) Dot.

	NORMAL RH WITH STEAM Dryclean Cycles							NORMAL RH WITH PRESS Dryclean Cycles					
	Orig	1	5	10	15	20	25	1	5	10	15	20	25
Individual Highs	2.8	2.4	3.0	1.3	2.8	2.4	2.0	3.7	2.6	2.6	4.0	3.6	4.0
	2.7	2.4	2.6	1.5	2.0	1.8	1.7	2.7	2.5	2.5	3.6	3.6	3.0
	2.6	2.3	2.5	1.3	2.2	1.8	1.6	2.7	2.0	2.7	3.6	3.6	2.7
	2.6	2.0			2.1	1.8	1.5	2.4		2.5	3.6	3.4	
	2.5	2.0									3.5		
Individual Lows	1.7	1.5	1.7	1.0	1.5	1.5	1.3	1.4	1.5	0.3	2.8	2.5	1.5
	1.5	1.5	1.7	0.1	1.5	1.0	1.3	0.5	1.5	1.5	2.5	2.5	1.4
	1.2	1.3	1.7	1.0	0.4	0.4	1.0	0.1	0.5	1.5	2.0	2.6	0.2
							0.2				1.0	2.0	

	HIGH RH WITH STEAM Dryclean Cycles							HIGH RH WITH PRESS Dryclean Cycles					
	1	5	10	15	20	25	Rec*	1	5	10	15	20	25
Individual Highs	2.7	2.2	2.7	2.3	2.4	2.6	4.1	2.6	2.6	3.2	3.2	2.4	3.4
	2.7	2.1	2.5	2.2	2.2	2.7	4.0	2.5	2.6	2.9	3.1	1.8	3.3
	2.1	2.3	2.2	2.1	2.0	2.5	3.5	2.5	2.6	2.4	3.0	1.8	3.2
	2.0			2.0	2.0	2.4	3.0	2.4	2.4	2.4	2.7	1.8	
	2.0						3.0	2.0	2.5	2.2			
Individual Lows	1.4	1.0	1.7	1.3	1.3	1.5	2.0	1.5	1.5	1.6	2.2	1.5	1.1
	1.0	1.1	1.5	1.5	1.2	1.5	1.6	1.1	1.4	1.7	2.0	1.5	1.0
	1.0	1.5	1.0	1.6	1.0	1.0	0.3	1.0	1.3	1.5	1.9	1.5	1.2
	1.0			1.5	1.6	0.3		0.7	1.0		1.7		1.5
									0.7		1.7		

* Dryclean 25 cycles with steam, followed by one press.

APPENDIX D

Relative Humidity Level Data

Normal Relative Humidity		High Relative Humidity	
Cycle No.	R.H. Level, %	Cycle No.	R.H. Level, %
1	56	1	85
6	56	5	83
7	40	8	89
8	61	10	81
10	38	13	92
12	26	15	84
13	38	18	79
16	57	20	88
19	68	22	86
20	38	24	81
22	56	25	80
23	47		
25	68		
R.H. %, Ave.	50.0		84.4

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